Appendix 2-3

Soils Study

SOILS STUDY

GENWAL COAL CO.

CRANDALL CANYON MINE

PERMIT AREA

PREPARED BY

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MAP Unit Descriptions

DPH2 -- Doney variant - Podo - Rock outcrop complex, 50 to 70 percent slopes, eroded.

This map unit is on very steep mountain sides. Slopes are convex and medium in length. The present vegetation is Salina wildrye, curlleaf mountain mahogany, Rockymountain red juniper, pinyon pine, Douglas fir and bluebunch wheat grass. Elevation is about 7800 to 8800 feet. The average annual precipitation is about 14 to 18 inches (35 to 45 cm) the mean annual air temperature is 38 to 42 degrees F. (3 to 6°C.) The mean annual soil temperature at 20 inches is 40 to 44 degrees F. (4.5 to 7°C.) and the freeze free season is 70 to 100 days.

This unit is 40 percent Doney variant very stony sandy loam, 50 to 70 percent slopes, eroded; 30 percent Podo extremely stony loam, 50 to 70 percent slopes, eroded, 15 percent Rock outcrop and 15 percent other soils and miscellaneous land types. These soils are intermixed in the landscape and cannot be separated out.

Included in this unit is about 10 percent of a soil similar to Podo extremely stony loam, 50 to 70 percent slopes, eroded except it is less than 10 inches deep over sandstone and 5 percent rubble land.

The Doney soil is moderately deep and well drained. It is formed in colluvium and alluvium dominantly from sandstone.

A typical pedon located 1100 feet east and 280 feet north of the 1/4 corner between sec. 5 and 6, T. 16 S. and R. 7 E.

Taxonomic Classification: Fine-loamy, mixed (calcareous), frigid, Typic Ustorthents.

Pedon No.4

A1--0 to 9 inches; light brownish gray (10YR 6/2) very stony sandy loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; 15 percent gravel, 15 percent cobbles, 10 percent stones and 10 percent boulders; strongly calcareous; moderately alkaline (pH 8.1); clear smooth boundary.

C1--9 to 23 inches; pale brown (10YR 6/3) cobbly loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; hard, friable, slightly sticky, slightly plastic; 10 percent gravel, 5 percent cobbles; strongly calcareous; moderately alkaline (pH 8.3); clear wavy boundary.

C2--23 to 39 inches; light brownish gray (10YR 6/2) gravelly loam, dark grayish brown (10YR 4/2) moist; massive; hard, friable, slightly sticky, slightly plastic; 20 percent gravel, 5 percent cobbles; strongly calcareous with some lime coatings on the rock fragments; moderately alkaline (pH 8.3); abrupt wavy boundary.

R--39 inches; sandstone.

Range In Characteristics:

Depth to sandstone ranges from 20 to 40 inches. The A1 horizon is 5 to 10 inches thick. Rock fragment in the A1 horizon ranges from 35 to 60 percent and in the C horizon from 5 to 35 percent.

Permeability of the Doney variant soil is moderate to the depth of the sandstone. Available water capacity is 2 to 5 inches to the depth of the sandstone. Water supplying capacity is 4 to 8 inches. Runoff is rapid and the hazard of water erosion is high. The erodibility is moderate. Small slumps 8 to 16 inches and rills are common.

The Podo soil is shallow and well drained. It is formed in colluvium and residuum derived dominantly from sandstone.

A typical pedon located 540 feet east and 25 feet north of the 1/4 corner between sec. 5 and 6, T. 16 S. and R. 7 E.

Taxonomic Classification: Loamy, mixed (calcareous), frigid, Lithic Ustorthe

Pedon No.5

A1--0 to 8 inches; pinkish gray (7.5YR 6/2) extremely stony loam, reddish brown (5YR 4/3) moist; massive; slightly hard, friable, slightly

sticky, slightly plastic; 20 percent gravel, 25 percent cobbles, 20 percent stones and 5 percent boulders; strongly calcareous; moderately alkaline (pH 8.1); clear smooth boundary.

C--8-19 inches; pinkish gray (7.5YR 6/2) cobbly loam, reddish brown (5YR 4/3) moist; massive; hard, friable, slightly sticky, plastic; 15 percent gravel, 15 percent cobbles and 5 percent stones; strongly calcareous; moderately alkaline (pH 8.2) abrupt smooth boundary.

R--19 inches, sandstone.

Permeability of the Podo soil is moderate to the depth of the sandstone. Available water capacity is 1 to 2 inches to the depth of the sandstone. Water supplying capacity is 3 to 5 inches. Runoff is rapid and the erosion hazard is high. The erodibility is moderate. Small slumps 8 to 16 inches and rills are common.

Range In Characteristics:

Depth to sandstone ranges from 10 to 20 inches. The hue is 10YR through 5YR. The A1 horizon is 5 to 10 inches thick. Rock fragments in the A1 horizon ranges from 40 to 75 percent and from 15 to 50 percent in the C horizon, but averages less than 35 percent in the C horizon.

Rock outcrop consists of barren or nearly barren areas of bedrock that occur mainly as escarpment and ledges.

Rubble land is an accumulation of large boulders.

This unit has a very limited use for rangeland and wildlife habitat. This map unit is in capability subclass VIIs nonirrigated.

JDE--Jodero Variant - Datino Variant Complex 5 to 20 percent slopes.

This map unit is on a small terrace below a very steep mountain slope. Slopes are convex-concave and short. The present vegetation is Douglas fir, Rocky mountain red juniper, snowberry, Kentucky bluegrass and a trace of quaking aspen and blue spruce. Elevation is about 7800 to 7900 feet. The average annual precipitation is 14 to 18 inches (35 to 45 cm), the mean

annual air temperature is 38 to 42 degrees F. (3 to 6°C.) The mean annual soil temperature at 20 inches is 40 to 44 degrees F. (4.5 to 7°C.) and the freeze free season is 70 to 100 days.

This unit is 50 percent Jodero variant sandy loam 5 to 20 percent slopes; 40 percent Datino variant very bouldery loam, 5 to 20 percent slopes and 10 percent other soils.

Included in this unit is about 10 percent Twine Creek stony loam, 5 to 20 percent slopes and some small areas of Doney variant very stony loam, 20 to 50 percent slopes. These soils are intermixed in the landscape and cannot be separated out.

The Jodero variant soil is very deep and well drained. It is formed in alluvium dominantly from sandstone.

A typical pedon located 530 feet east and 50 feet south of the 1/4 corner between sec. 5 and 6, T. 16 S. and R. 7 E.

Taxonomic Classification: Course-loamy, mixed, Cumulic Haploborolls.

Pedon No.2

A11--0 to 10 inches; dark grayish brown (10YR 4/2) sandy loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightly hard, friable, slightly sticky, slightly plastic, very slightly calcareous; mildly alkaline (pH 7.8); clear smooth boundary.

A12--10 to 19 inches; grayish brown (10YR 5/2) sandy loam, very dark brown (10YR 2/2) moist; there are small pockets of pale brown soil; weak fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; very slightly calcareous; moderately alkaline (pH 8.0); gradual wavy boundary.

A13--19 to 32 inches; dark grayish brown (10YR 4/2) sandy loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; 10 percent gravel; very slightly calcareous; moderately alkaline (pH 8.2); clear smooth boundary.

C1--32 to 50 inches; grayish brown (10YR 5/2) stony sandy loam, very dark grayish brown (10YR 3/2) moist; massive; hard, friable, slightly sticky, slightly plastic; 10 percent gravel, 5 percent cobbles and 5 percent stones; moderately calcareous, lime is in veins and coatings on rocks and disseminated; moderately alkaline (pH 8.3); clear smooth boundary.

C2--50 to 65 inches; pale brown (10YR 6/3) stony sandy loam, brown (10YR 4/3) moist; massive; slightly hard, slightly sticky, slightly plastic; 10 percent gravel, 10 percent cobbles and 10 percent stones; moderately calcareous, lime is in veins and coatings on the rocks and disseminated; moderately alkaline (pH 8.3).

Range In Characteristics:

The thickness of the A1 horizon is 28 to 36 inches. In a few locations there are a few stones and cobbles on the surface. The rock fragments in the C horizon range from 15 to 30 percent.

Permeability of the Jodero variant soil is moderately rapid. Available water capacity is 6 to 8 inches to a depth of 60 inches. Water supplying capacity is 8 to 12 inches. Runoff is slow to medium and the hazard of water erosion is slight. The erodibility of the soil is low.

The Datino variant soil is very deep and well drained. It is formed in alluvium and colluvium derived dominantly from sandstone.

A typical pedon located 300 feet east of the 1/4 corner between sec. 5 and 6, T. 16 S. and R. 7 E.

Taxonomic Classification: Loamy-skeletal, mixed, Cumulic Haploborolls.

Pedon No.1

A1--0 to 8 inches; very dark grayish brown (10YR 3/2) very bouldery loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightl hard, friable, slightly sticky, slightly plastic; 2 percent gravel, 5 percent cobbles, 15 percent stones and 15 percent boulders; very slightly calcareous; mildly alkaline (pH 7.6); clear wavy boundary.

C1--8 to 23 inches; dark grayish brown (10YR 4/2) very cobbly sandy loam very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky slightly plastic; 10 percen gravel, 30 percent cobbles and 10 percent stones; very slightly calcareous; moderately alkaline (pH 7.9); gradual wavy boundary.

C2--23 to 41 inches; brown (10YR 5/3) cobbly sandy loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; 5 percent gravel, 20 percent cobbles and 10 percent stones; moderately calcareous lime is in veins; moderately alkaline (pH 8.2); gradual wavy boundary.

C3--41 to 60 inches; brown (10YR 5/3) stony sandy loam, very dark grayish brown (10YR 3/2) moist; massive; slightly hard, very friable, slightly sticky, slightly plastic; 5 percent gravel, 15 percent cobbles and 15 percent stones; moderately calcareous lime in veins and disseminated; moderately alkaline (pH 8.4).

Range In Characteristics:

The thickness of the A1 horizon ranges from 7 to 10 inches. The rock fragments range from 35 to 50 percent in the A1 horizon and from 25 to 50 percent in the C horizon.

Permeability of the Datino variant soil is moderately rapid. Available water capacity is 4.5 to 5.5 inches to a depth of 60 inches. Water supplying capacity is 6 to 9 inches. Runoff is slow to medium and the erosion hazard by water is slight. The erodibility is low.

This unit is used for rangeland and wildlife habitat.

The capability subclass for Jodero variant soil is VIe and for Datino variant soil is VIIs non-irrigated.

TcE--Twin Creek stony loam, 5 to 20 percent slopes.

This very deep and well drained soil is on a small terrace below a very steep mountain slope. It is formed in alluvium and colluvium dominantly from sandstone. Slopes are convex - concave and short. The present vegetati is snowberry, Douglas fir, Rocky mountain red juniper, Kentucky bluegrass, an a trace of quaking aspen and blue spruce. Elevation is about 7800 to 8000 feet. The average annual precipitation is about 14 to 18 inches (35 to 45 cm the mean annual air temperature is 38 to 42 degrees F. (3 to 6°C.) The mean annual soil temperature at 20 inches is 40 to 44 degrees F. (4.5 to 7°C) and the freeze free season is 70 to 100 days.

A typical pedon located 930 feet east and 60 feet north of the 1/4 corne between sec. 5 and 6, T. 16 S. and R. 7 E.

Taxonomic Classification: Fine-loamy, mixed, Typic Haploborolls.

Pedon No.3

A1--0 to 8 inches; dark grayish brown (10YR 4/2) stony loam, very dark grayish brown (10YR 3/2) moist; moderate medium granular structure; hard, friable, slightly sticky, plastic; 10 percent gravel, 10 percent cobbles, 10 percent stones and 2 percent boulders; very slightly calcareous; moderate alkaline (pH 8.0); clear smooth boundary.

B2--8 to 22 inches; light brownish gray (10YR 4/2) cobbly loam, brown (7.5 YR 4/2) moist; weak medium subangular blocky structure; very hard, friable, slightly sticky, plastic; 5 percent gravel and 10 percent cobbles; moderately calcareous, lime is disseminated and in fine veins; moderately alkaline (pH 8.2); clear smooth boundary.

* C1ca--22 to 51 inches; light brownish gray (10YR 6/2) loam, brown (7.5 YR 4/2) moist; weak medium subangular blocky structure; very hard, friable, slightly sticky, plastic; 5 percent gravel, 5 percent cobbles; moderately calcareous, lime is in veins, flecks and disseminated; moderately alkaline (pH 8.4); gradual wavy boundary.

C2ca--51 to 65 inches; light brownish gray (10YR 6/2) cobbly loam, brown (7.5YR 4/2) moist; moderate medium subangular blocky structure; very hard, friable, slightly sticky, plastic; 5 percent gravel, 10 percent cobbles and 5 percent stones; moderately calcareous lime is in veins, flecks and disseminated; strongly alkaline (pH 8.5).

*Note: This horizon was subdivided for sampling 22 to 36 inches and 36 to 51 inches.

Range In Characteristics:

Thickness of the A1 horizon ranges from 7 to 10 inches. The percent of rock fragments in the A1 horizon range from 20 to 35 percent and from 15 to 35 percent in the B horizon.

Included in this unit is about 10 percent of Datino variant 5 to 20 percent slopes and 10 percent Doney variant very stony loam, 20 to 50 percent slopes.

Permeability of the Twin Creek soil is moderate. Available water capacity is 7 to 9 inches. Water supplying capacity is 8 to 12 inches. Runoff is slow to medium and the hazard of water erosion is slight. The erodibility is low.

This unit is used for rangeland and wildlife habitat. This unit is in capability subclass VIs non-irrigated.

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ANALYSIS LABORATORY
UMC 48

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Data results on soil samples received 6/19/81.

SU Log #	Ident.	MAh Hydrometer %Sand	%Silt	%Clay	Class	$NaHCO_3$ ppm Phosphorus	Potassium	ECe	%Organic Matter	% SP	H_2O Sol. meq/l Sodium	Calcium	Magnesium	SAR	Fizz Lime	pH
1-1235	1-0-8	51	35	14	L	22.2	178	.4	14.1	79.4	.29	2.8	.73	.2	+	7.6
1236	8-23	65	22	13	SL	7.4	87	.4	2.5	31.0	.36	2.7	1.00	.3	+	7.9
1237	23-41	68	19	13	SL	3.8	63	.3	1.5	26.1	.43	2.2	.66	.4	++	8.2
1238	41-60	72	18	10	SL	.9	55	.2	1.4	28.1	.37	1.4	.40	.4	++	8.4
1239	2-0-10	60	27	13	SL	4.3	99	.4	6.0	45.5	.27	3.5	.91	.2	+	7.8
1240	10-19	57	28	15	SL	1.9	90	.3	4.2	36.1	.43	2.6	.49	.3	+	8.0
1241	19-32	65	24	11	SL	1.8	87	.3	4.4	33.7	.39	2.3	.54	.3	+	8.2
1242	32-50	61	26	13	SL	1.1	65	.3	2.6	32.3	.44	1.8	.53	.4	++	8.3
1243	50-65	70	18	12	SL	1.3	55	.2	1.4	25.3	.55	1.7	.58	.5	++	8.3
1244	3-0-8 TcE	47	36	17	L	5.0	152	.4	6.2	47.8	.34	2.4	.77	.3	+	8.0
1245	8-22	48	33	19	L	.9	95	.4	2.2	35.3	.36	2.4	.67	.5	++	8.2
1246	22-36	48	34	18	L	.9	78	.3	2.1	35.6	.44	1.9	.63	.4	++	8.3
1247	36-51	47	33	20	L	.9	65	.2	2.1	35.2	.49	1.3	.53	.5	++	8.4
1248	51-65	45	37	18	L	1.0	58	.2	2.0	35.6	.44	1.2	.49	.5	++	8.5
1249	4-0-9 DPH 2	54	33	13	SL	2.0	184	.5	2.4	31.4	.42	3.2	.50	.3	++	8.1
1250	9-23 Doney	48	31	21	L	.5	120	.3	2.3	38.5	.40	2.0	.45	.4	++	8.3
1251	23-39	39	40	21	L	.9	55	.3	2.3	39.5	.45	2.0	.46	.4	++	8.3
1252	5-0-8 DPH 2	49	36	15	L	4.5	178	.3	2.3	31.0	.37	2.1	.32	.3	++	8.1
1253	8-19 Pado	47	33	20	L	1.4	68	.3	1.8	34.4	.45	2.0	.52	.4	++	8.2

Productivity Analysis of Soils

The Electrical Conductivity ECe (EC X 10^6) are very low in all samples. There are no problems with salinity. The Sodium-Absorption-Ratio SAR are also very low in all samples, indicating there are no problems with sodium salts (alkali). The pH is normal for calcareous soils. All samples have some presence of lime (CaCo3), no additional lime is needed.

The only significant limitation these soils have for use as top soil or sub soil is the rock fragments. Some sorting of the larger rocks could possibly be done while stock piling the soils.

ample No.	Soil Name	Map Symbol	Percent of M.U.	Depth Inches	Thickness Inches	Kind of Soil	Volume CY	Limitation	* Fertilizer-Needs
1	Datino Variant	JDE	40	0- 8	8	Top soil	973	Rock fragments	None
				8-23	15	Sub soil	1815	Rock fragments	30-40lbs N.
				23-60	37	Sub soil	4472	Rock fragments	40-50lbs P205
									50-75lbs K20
									30-40lbs N.
2	Jodero Variant	JDE	50	0-32	32	Top soil	4846	----	40-50lbs P205
				32-65	33	Sub soil	4991	Rock fragments	40-50lbs P205
									50-75lbs K20
									30-40lbs N.
3	Twin Creek	TCE	90	0- 8	8	Top soil	2182	Rock fragments	40-50lbs P205
		~~JDE~~	10	8-65	57	Sub soil	1719	----	40-50lbs P205
									50-75lbs K20
									30-40lbs N.

4 Doney variant and Podo soils map symbol DPH2 have over 50 percent rock fragments in the surface.
They are intermixed in the landscape with rock outcrop and rubble land. Slopes are 50 to 70 percent;
5 because of the severe limitations these soils are not suitable for stockpiling.

*Fertility recommendation and studies made in Utah have been based on the surface foot of soil. Phosphorus levels from 0 to 7 ppm usually need additional phosphorus. There are not any good guidelines on potassium recommendations. It is thought that where the surface soil is below 100 ppm additional potassium would be advisable. Where about 1 foot of top soil is used in the disturbed area it would not be necessary to apply fertilizer to the sub soil. Fertilizer should be applied every 2 to 3 years following seeding except where the top soil from sample No. 1 is used.

Methodology

Field

The soil survey was conducted according to procedures established by the National Cooperative Soil Survey. Map scale and kinds of field sheets were supplied to meet the objectives of the survey.

Mapping Units are soil phases and are selected as those properties which influence man's use and management. Examples of phrase criteria are slope, texture of surface soils, rock fragments, and erosion. The Soils Map is designed to show the distribution of soils and miscellaneous land units.

Soils descriptions and analytical data permit classification and interpretation of the soils according to Soil Taxonomy.

Laboratory

Particle size distribution was performed by the hydrometer method, which consists of dispersing the sample and measuring the rate of settling, with a hydrometer. Results are expressed as percentages of sand, silt, and clay; and textural classes are determined from a textural triangle.

pH was measured on a saturated paste, using a line meter adjusted with appropriate buffers. pH 7.0 is considered neutral; pH 8.6, alkali.

Electrical conductivity (ECe) is measured on the saturation extract and is expressed as mmhos/cm. Above 8 mmhos, some amendments may be necessary for seeding success of native plants.

Calcium carbonate equivalent was not measured quantitatively. The presence of free calcium carbonate was detected by effervescence with dilute (10%) hydrochloric acid. Calcium carbonate tends to ameliorate the effects of sodium.

Sodium absorption ratio (SAR) is an expression of the activity of sodium with respect to other ions in solution. SAR values of 13 are approximately equivalent to % exchangeable sodium (ESP) of 15.

Extractable cations are measured on the saturation extract.

Available potassium and phosphorus are extracted with sodium bicarbonate and expressed as parts per million.

Soil Resource Information of Mine Plan Area

Soils Identification

The different kinds of soils were classified into the higher categories of the classification system.

These categories include family, the subgroup, great group, suborder, and order. The orders tend to group soils with similar sets of soil-forming processes. The soils at the order level were Entisols, and Mollisols. Entisols are soils that lack distinct horizon differentiation. Mollisols have a thick, dark surface horizon, high in organic matter.

Suborder

Soil orders are divided into suborders primarily on the basis of soil characteristics that produce classes with the greatest genetic similarity. The soil properties are those that reflect either the presence or absence of waterlogging or differences resulting from climate or vegetation. The suborders in the survey area are Orthents and Borolls.

Great Group

The Great Group is a subdivision of the Suborder. Suborders are separated into Great Groups on the basis of uniformity in kinds and sequence of major soil horizons and properties. The horizons used to make separations are those in which clay, iron, humus, or lime have accumulated, or those that have layers that

interfere with root growth or the movement of water. An example of a Great Group name is Haploborolls which is the Great Group name for Mollisols, that lack an argillic horizon.

Subgroup

Great Groups are divided into Subgroups, one representing the central (typic) segment of the Group, and other, called intergrades, that have properties of the Group and also one or more properties of another Great Group, Suborder, or Order.

Family

Families are separated within Subgroups primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, and soil temperature. A frigid temperature regime indicates that the mean annual soil temperature at 20 inches deep is less than 47°F.

Soils Description

The Map Unit description is designed to assist the reader in visualizing the setting of the soils. But it is designed primarily to show the included soils not appearing in the name of the Map Unit.

Interpretations are included as part of the Map Unit description These are permeability, available water capacity, water supplyin capacity, erosion hazard, erodibility and land capability subclass.

The Pedon Descriptions are designed to show the properties observed at the time of sampling. The horizons are the basis of sampling for laboratory analysis.

Included in the Map Unit Descriptions are the SCS Land Capabilit Classifications. The capability classes show in a general way, the suitability of the soils for most kinds of crops. The class

are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The soils in the area were placed in capability classes VI and VII. Class VI soils have severe limitations that generally make them unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife. Class VII soils have very severe limitations that make them unsuited to cultivation and restrict their use largely to range, woodland, or wildlife.

The small letter "e" added to the capability class denotes a subclass. It shows that the main limitation is risk of erosion. Erosion is considered to be the main risk to use of all the soils in the area.

Other important risk factors considered were soil factors "s", such as shallow soils, droughty or stony soils.

The Soil Survey and Soil Survey Report by Laural H. Stott,.Soil Consultant; recently retired as Soil Scientist and Soil Survey Party Leader, Soil Conservation Service.